Natural Conditions Assessment for Low pH and Low Dissolved Oxygen, Jacks Creek and Tributaries in King William County, Virginia

Submitted by
Virginia Department of Environmental Quality

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Executive Summary

This report presents the assessment of whether low pH and dissolved oxygen (DO) in Jacks Creek and tributaries are due to natural conditions or whether a Total Maximum Daily Load (TMDL) must be performed because of anthropogenic impacts. Jacks Creek is located within King William County, Virginia, and is a major tributary of the Pamunkey River, a major tributary of the York River. The waterbody identification (WBID) code for Jacks Creek is VAP-F13R. Jacks Creek encompasses a total of approximately 67.88 rivermiles (National Hydrography Dataset (NHD). Jacks Creek and tributaries were listed as impaired due to violations in water quality standards for dissolved oxygen and pH. This report addresses both the dissolved oxygen and pH impairments.

The total area of the Jacks Creek watershed is approximately 27.70 square miles. The average annual rainfall is 44 inches. The watershed is predominately forested (60 percent). Agriculture comprises 16 percent of the watershed, with 11 percent cropland and 5 percent pasture/hayland. Urban areas compose approximately 4 percent of the land base. The remaining 20 percent of the watershed is comprised of 9 percent other grasses and 11 percent wetlands, Land use was not considered to have significantly impacted the swampwater conditions of Jacks Creek and tributaries.

The mainstem of Jacks Creek, with tributaries Acquinton and Mallory Creeks, was listed as impaired on Virginia's 2002 303(d) Total Maximum Daily Load Priority List and Report, and the 2004, 2006, 2008, and 2010 305(b) / 303(d) Integrated Reports (VADEQ, 2002, 2004, 2006, 2008, and 2010) due to violations of the State's water quality standard for DO. Mallory Creek was also listed as impaired for low pH on Virginia's draft 2012 Integrated Report.

DEQ monitored 8 stations on Jacks, Acquinton, Mallory Creeks and a UT to Jacks Creek with dates ranging from June 1995 through November 2011. Five of the 8 stations exceeded the DO water quality standard on more than 10.5 percent of visits, including sites on Jacks, Acquinton and Mallory Creeks. Only one of the 8 stations violated the pH water quality standard on more than 10.5 percent of visits. Six pH violations occurred at Mallory Creek station 8-MLY001.58 resulting in a violation rate of 27%. Figures E1 and E2 show respective DO concentrations at the listing station 8-JKC004.15 and pH concentrations at Mallory Creek station 8-MLY001.58.

Figure E1. DO concentrations at Jacks Creek station 8-JKC004.15.

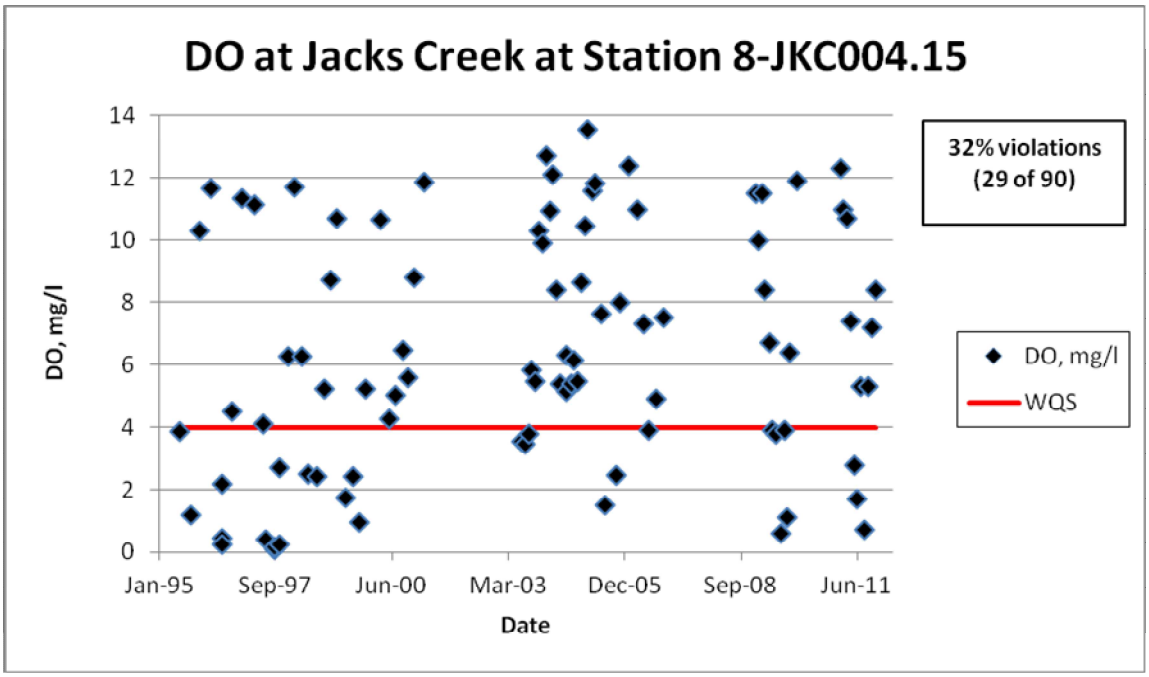
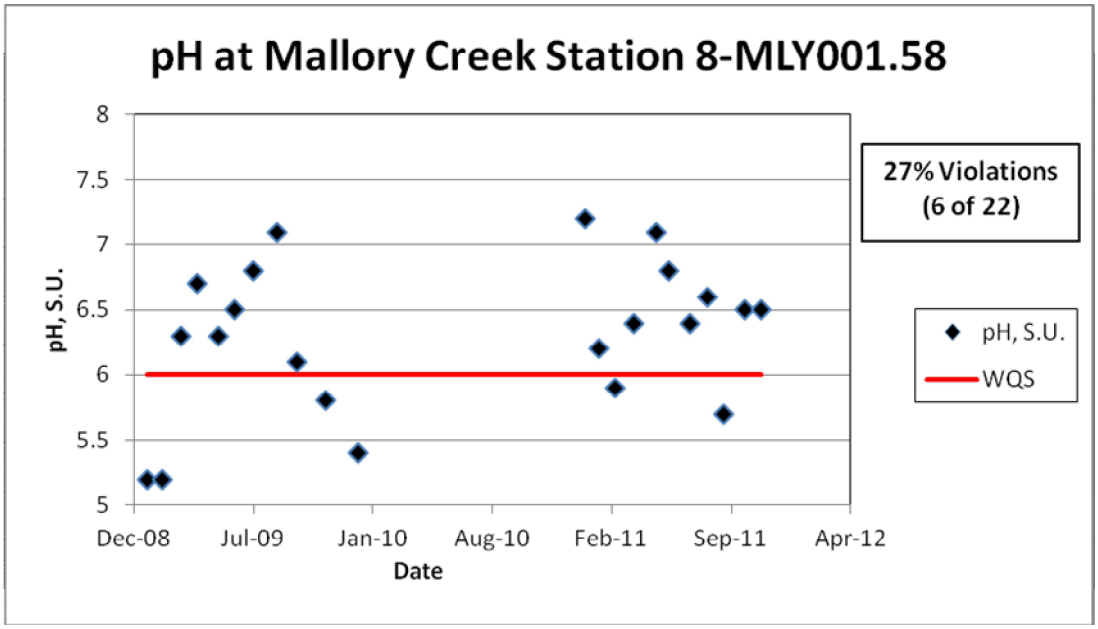


Figure E2. pH concentrations at Mallory Creek station 8-MLY001.58.



According to Virginia Water Quality Standards (9 VAC 25-260-10A), "all state waters are designated for the following uses: recreational uses (e.g., swimming and boating); the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might be reasonably expected to inhabit them; wildlife; and the production of edible and marketable natural resources (e.g., fish and shellfish)."

As indicated above, Jacks Creek and tributaries must support all designated uses and meet all applicable criteria. If the waterbody violates the instantaneous DO water quality standard of 4.0 mg/l or pH values are less than 6.0 or greater than 9.0 in more than 10.5 percent of samples, the waterbody is classified as impaired and natural conditions must be determined or a TMDL must be developed and implemented to bring the waterbody into compliance with the water quality criterion.

In 2003 VADEQ proposed a methodology for determining whether low DO or pH originates from natural or anthropogenic sources, adapted from "Methodology for Assessing Natural Dissolved Oxygen and pH Impairments: Application to the Appomattox River Watershed, Virginia" (MapTech 2003).

The level of dissolved oxygen in a water body is determined by a balance between oxygen-depleting processes (*e.g.*, decomposition and respiration) and oxygen restoring processes (*e.g.*, aeration and photosynthesis). Certain natural conditions promote a situation where oxygen-restoring processes are not sufficient to overcome the oxygen-depleting processes. Conditions that would typically be associated with naturally low DO include slow-moving, ripple-less waters where the bacterial decay of organic matter depletes DO at a faster rate than it can be replenished. Indicators of these conditions include low slope, the presence of swamps or wetlands. These conditions often also produce low pH due to organic acids (tannins, humic and fulvic substances) produced in the decay process. These situations can be compounded by anthropogenic activities that contribute excessive nutrients or readily available organic matter to these systems.

The general approach to determine if DO and pH impairments in free-flowing streams are due to natural conditions is to assess a series of water quality and hydrologic criteria to determine the likelihood of an anthropogenic source. A logical 4-step process for identifying natural conditions that result in low DO and/or low pH levels and for determining the likelihood of anthropogenic impacts is described below. DEQ staff use this approach to implement State Water Control Law 9 VAC 25-260-55, Implementation Procedure for Dissolved Oxygen Criteria in Waters Naturally Low in Dissolved Oxygen.

Before implementing this procedure, all DO and pH data should be screened for flows less than the 7Q10. DO and pH data collected on days when flow was < 7Q10 should be eliminated from the data set and the violation rate recalculated accordingly.

Step 1. Determine slope and appearance (presence of wetlands).
Step 2. Determine nutrient levels and compare with USGS background concentrations.
Step 3. Determine degree of seasonal fluctuation (for DO only).
Step 4. Determine anthropogenic impacts from permitted dischargers and land use.

No Jacks Creek pH or DO water quality data, standard violations or non-violations were obtained at flows below 7Q10, therefore no data were removed.

The percent slope of Jacks Creek and tributaries ranged from 0.21% to 0.48% slope. This is less than the defined low slope criteria of 0.50%. Decomposition of the large inputs of decaying vegetation from areas of forested land with swamps and heavy tree canopy throughout the watersheds increase oxygen demand and lower DO as they decay, as well as contribute to the low pH by creation of natural weak organic acids (tannic, humic and fulvic acids) during decomposition of the decaying vegetation. These are not considered anthropogenic impacts.

The average total nitrogen, nitrate and total phosphorus concentrations in Jacks creek are below the USGS (1999) national background nutrient concentrations in streams from undeveloped areas with levels of TN < 1.0 mg/l, nitrate < 0.6 mg/l and TP < 0.1 mg/l. These low nutrient levels are not indicative of human impact.

Jacks Creek exhibits natural seasonal DO fluctuation due to the inverse relationship between water temperature and DO.

There are no active permitted point source dischargers in the Jacks Creek watershed.

The watershed is approximately 17726 acres (27.70 mi^2) in size and is predominately forested (60 percent). Agriculture comprises 16 percent of the watershed, with 11 percent cropland and 5 percent pasture/hayland. Urban areas compose approximately 4 percent of the land base. The remaining 20 percent of the watershed is comprised of 9 percent other grasses and 11 percent wetlands, Land use was not considered to have significantly impacted the swampwater conditions of Jacks Creek and tributaries.

Based on the above information, a change in the water quality standards classification to Class VII Swampwater due to natural conditions, rather than a TMDL, is indicated for Jacks Creek and tributaries located in waterbody identification codes (WBID) VAP-F12R, for a total of 67.88 rivermiles. The unnamed tributary to Jacks Creek entering at RM 5.92 was included in the Class VII designation because the minimum DO of this tributary decreased almost to the DO water quality standard and the land use, percent slope and other factors were consistent with the swampwater conditions in the rest of the watershed. If there is a 305(b)/303(d) assessment prior to the reclassification, Jacks Creek and tributaries will be assessed as Category 4C, Impaired due to natural condition, no TMDL needed.

DEQ performed the assessment of the Jacks Creek and tributaries low DO and low pH natural conditions in lieu of a TMDL. Therefore neither a TMDL Technical Advisory Committee (TAC) meeting nor a public meeting was involved. Public participation will occur during the next water quality standards triennial review process.

1. Introduction

Jacks Creek is located within King William County, Virginia, and is a major tributary of the Pamunkey River, a major tributary of the York River. There are 67.88 total stream miles in the Jacks Creek watershed (National Hydrography Dataset (NHD)) using GIS. Jacks Creek is fed by tributaries Acquinton and Mallory Creeks as well as an unnamed tributary of Jacks Creek. The impaired segments for low DO total 21.05 miles, the entire lengths of Jacks Creek and tributaries. The impaired segment for low pH totals 4.02 miles of Mallory Creek, a tributary of Jacks Creek. This low pH segment mileage is duplicated within the low DO segment mileage. Jacks Creek and tributaries generally flow southeast from the headwaters south of Rumford, VA, to the confluence with the Pamunkey River downstream of Liberty Hall. The watershed totals approximately 27.70 mi^2. There is no continuous flow gaging station on Jacks Creek or tributaries.

2. Physical Settings

2.1. Listed Water Bodies

The mainstem of Jacks Creek with tributaries Acquinton and Mallory Creeks was listed as impaired on Virginia's 2002 303(d) Total Maximum Daily Load Priority List and Report, and the 2004, 2006, 2008, and 2010 305(b) / 303(d) Integrated Reports (VADEQ, 2002, 2004, 2006, 2008, and 2010) due to violations of the State's water quality standard for DO. Mallory Creek was also listed as impaired for low pH on Virginia's draft 2012 Integrated Report. This report evaluates both the DO and pH impairments by determining if natural conditions are the cause of the impairment, thus obviating the need for a TMDL. The waterbody identification code (WBID, Virginia Hydrologic Unit) for non-tidal Jacks Creek is VAP-F13R.

2.2. Watershed

2.2.1. General Description

Jacks Creek and tributaries generally flow southeast from the headwaters south of Rumford, VA, to the confluence with the Pamunkey River downstream of Liberty Hall. The watershed totals approximately 27.70 mi^2. There is no continuous flow gaging station on Jacks Creek or tributaries. See Figure 1 for a map of the watershed including 8 monitoring stations.

Figure 1. The Jacks Creek watershed map and associated monitoring stations.

2.2.2. Geology, Climate, Land Use

Geology and Soils

The impaired segment of Jacks Creek is within the Atlantic Coastal Plain physiographic region. The Atlantic Coastal Plain is the easternmost of Virginia's physiographic provinces. The Atlantic Coastal Plain extends from New Jersey to Florida, and includes all of Virginia east of the Fall Line. The Fall Line is the easternmost extent of rocky river rapids, the point at which east-flowing rivers cross from the hard, igneous and metamorphic rocks of the Piedmont to the relatively soft, unconsolidated strata of the Coastal Plain. The Coastal Plain is underlain by layers of Cretaceous and younger clay, sand, and gravel that dip gently eastward. These layers were deposited by rivers carrying sediment from the eroding Appalachian Mountains to the west. As the sea level rose and fell, fossiliferous marine deposits were interlayered with fluvial, estuarine, and beach strata. The youngest deposits of the Coastal Plain are sand, silt and mud presently being deposited in our bays and along our beaches (http://www.dcr.virginia.gov/natural_heritage/documents/overviewPhysiography_vegetation.pdf).

Soils for the Jacks Creek watershed were documented utilizing the VA State Soil Geographic Database (STATSGO). Three general soil types were identified using in this database. Descriptions of these soil series were derived from queries to the USDA Natural Resources Conservation Service (NRCS) Official Soil Series

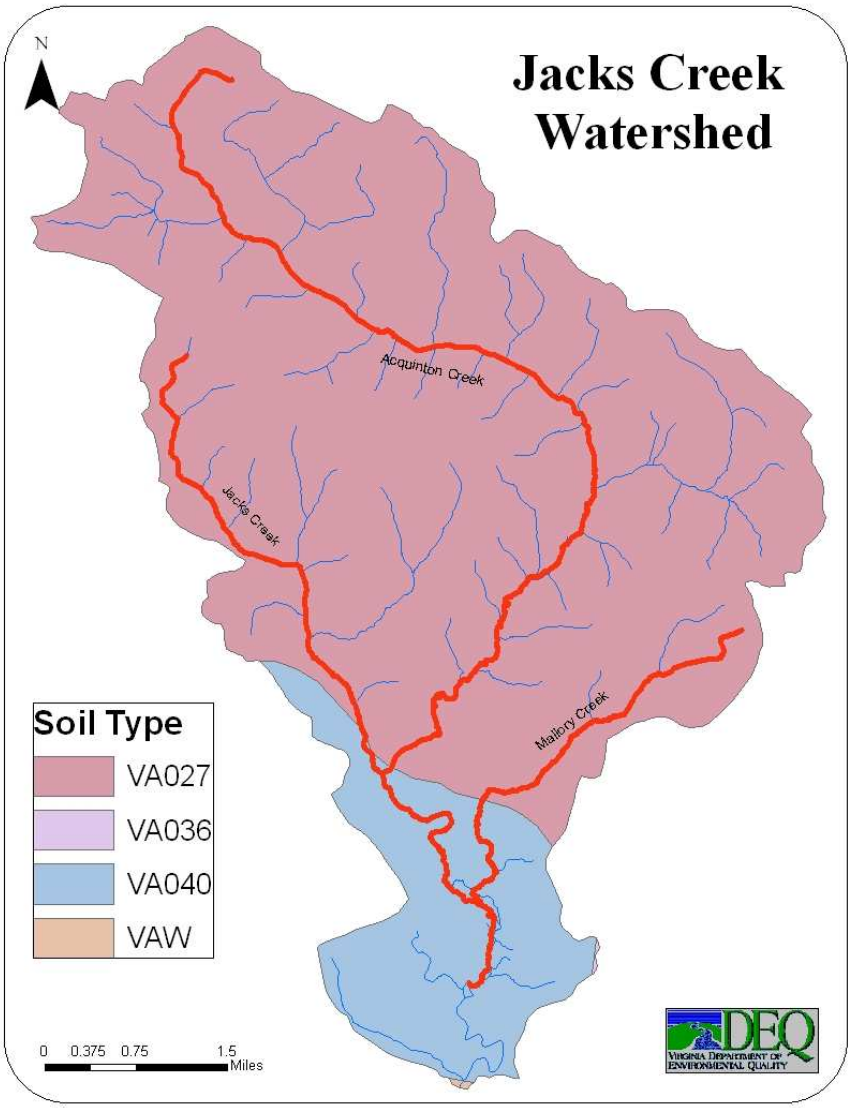
Description web site (http://soils.usda.gov/technical/classification/osd/index.html). Figure 2 shows the location of these general soil types in the watershed.

Soils of the Emporia-Johnston-Kenansville-Remlik-Rumford-Slagle-Suffolk-Tomotley (VA027) series are very deep to deep, and vary between well drained to poorly drained with moderately slow or slow permeability. They formed in moderately fine-textured stratified fluvial and marine sediments on the upper Coastal Plain and stream terraces.

Soils of the Tetotum-Nansemond-State-Emporia-Dragston-Nimmo-Bladen (VA036) series are very deep and range from well drained to poorly drained. Permeability ranges from moderately rapid and/or rapid to moderately slow or slow. This soil series was formed in sandy or loamy fluvial and marine sediments on Coastal Plain uplands and stream terraces.

Soils of the Bojac-Pamunkey-Munden-Angie-Augusta-Molena-Argent series (VA040) are very deep and range from excessively drained to poorly drained conditions. Permeability is moderately rapid to slow. This series**,** located on stream terraces and uplands**,** is composed of loamy and sandy fluvial and marine Coastal Plain sediments.

Figure 2. Soil Characteristics of the Jacks Creek Watershed.



Climate

The climate summary for Jacks Creek comes from a weather station located in Walkerton, VA (448829) with a period of record from 1932 to 2010. The average annual maximum and minimum temperatures (°F) at the weather station are 69.6 and 46.0 and the annual rainfall (inches) is 43.78 (Table 1) (Southeast Regional Climate Center, http://www.sercc.com/climateinfo/historical/historical_va.html).

Table 1. Climate summary for Walkerton, Virginia (448829).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	48.3	51.2	60.2	70.9	78.4	85.6	88.5	87.0	81.3	71.3	61.3	50.5	69.6
Average Min. Temperature (F)	26.5	27.8	34.8	43.9	53.7	62.5	66.7	65.5	58.3	46.2	36.8	28.7	46.0
Average Total Precipitation (in.)	3.43	3.03	3.82	3.06	3.89	3.69	4.86	4.39	3.79	3.20	3.31	3.31	43.78

Land Use

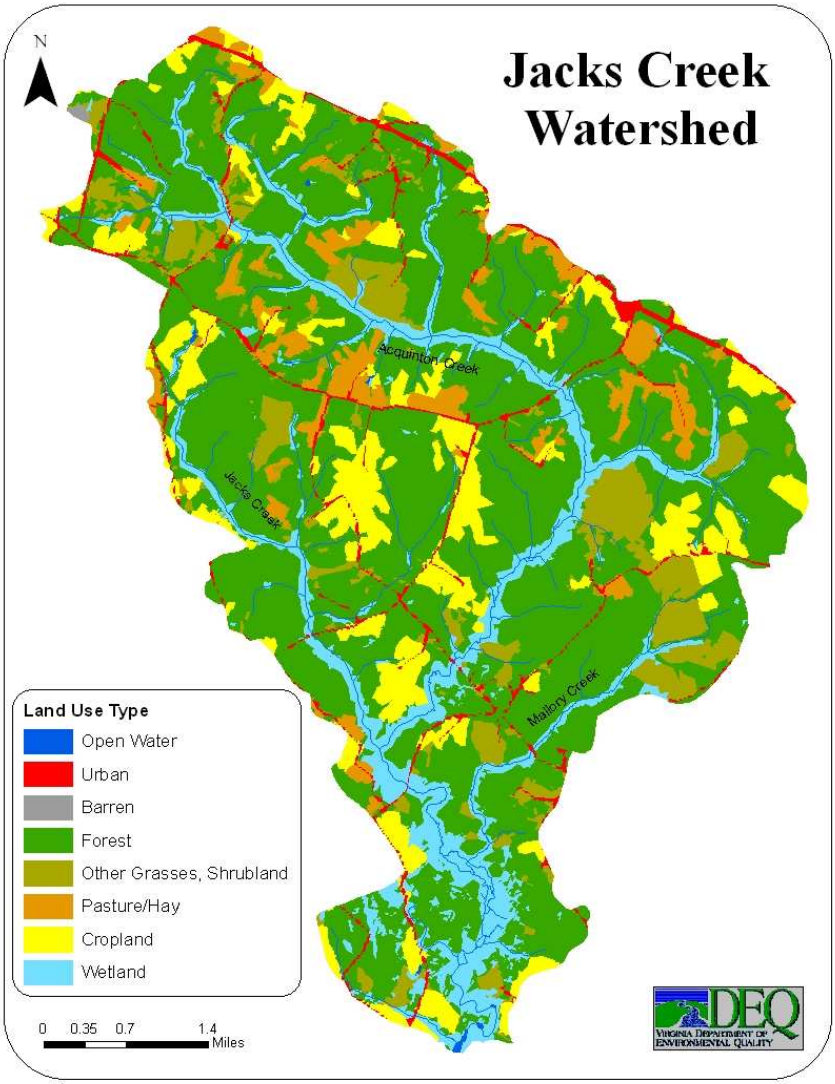
The Jacks Creek watershed extends from approximately Central Garage VA, to approximately 1.5 miles east of Montague Landing. It is approximately 10 miles long and 3.5 miles wide. The watershed is approximately 17726 acres (27.7 mi^2) in size and is predominately forested (60 percent). Agriculture comprises 16 percent of the watershed, with 11 percent cropland and 5 percent pasture/hayland. Urban areas compose approximately 4 percent of the land base. The remaining 20 percent of the watershed is comprised of 9 percent other grasses and 11 percent wetlands. Land use is described in Table 2.

A map of the distribution of land use in the watershed (Figure 3) shows that urban land use is concentrated around Rt.30 near the headwaters and along the remaining county roads. Wetlands are concentrated along the mainstem of Acquinton Creek and lower Jacks Creek below Acquinton Creek.

Table 2. Land Use in the Jacks Creek Watershed

Land Use Type	Acres	Square Miles	Percent
Open Water	20.30	0.03	0%
Urban	642.97	1.00	4%
Barren	9.90	0.02	0%
Forest	10606.56	16.57	60%
Pasture/Hay	860.06	1.34	5%
Cropland	1941.14	3.03	11%
Other Grasses	1681.81	2.63	9%
Wetland	1963.05	3.07	11%
Totals:	**17725.78**	**27.70**	**100%**
Land Use Type	**Acres**	**Square Miles**	**Percent**

Figure 3. Land Use in the Jacks Creek Watershed



3. Description of Water Quality Problem/Impairment

The mainstem of Jacks Creek with tributaries Acquinton and Mallory Creeks was listed as impaired on Virginia's 2002 303(d) Total Maximum Daily Load Priority List and Report, and the 2004, 2006, 2008, and 2010 305(b) / 303(d) Integrated Reports (VADEQ, 2002, 2004, 2006, 2008, and 2010) due to violations of the State's water quality standard for DO. Mallory Creek was also listed as impaired for low pH on Virginia's draft 2012 Integrated Report. This report evaluates both the DO and pH impairments by determining if natural conditions are the cause of the impairment, thus obviating the need for a TMDL.

DEQ monitored 8 stations on Jacks, Acquinton, Mallory Creeks and a UT to Jacks Creek (see Figure 1) with dates ranging from June 1995 through November 2011. Of the 250 total DO data points recorded, 60 violated water quality standards for DO (24%), and 8 of 250 pH data points violated the water quality standards for pH concentration (3%). The DO minimum and maximum values ranged from 0.0 to 15.2 mg/l, and pH values ranged from 5.2 to 9.0 S.U.. However, six pH violations occurred at one station (Mallory Creek 8-MLY001.58) resulting in a violation rate of 26%. The results are summarized in Table 3.

Table 3. pH and DO data collected by DEQ from 8 stations on Jacks Creek and tributaries.

		Number of Samples		SU		mg/l		Number of Violations	
Station	Sample Period	pH	DO	Average pH	Min-Max pH	Average DO	Min-Max DO	pH	DO
8-ACQ001.35	6/30/1995 to 11/3/11	25	25	6.96	6.3 – 7.6	7.98	2.2 – 12.7	0	2
8-ACQ004.43	6/30/1995 to 11/3/11	24	24	6.81	6.4 – 7.2	6.55	0.5 – 13.6	0	7
8-ACQ008.01	6/30/1995 to 11/3/11	24	24	6.48	5.9 – 7.0	5.31	0.4 – 12.7	1	9
8-JKC004.15	6/28/1995 to 11/3/11	90	90	6.76	5.6 – 7.6	6.41	0.0 – 13.5	1	29
8-JKC005.80	6/30/1995 to 11/3/11	22	22	6.86	6.0 – 7.6	9.22	2.6 – 15.2	0	1
8-JKC007.95	1/8/09 to 11/3/11	23	23	7.24	6.3 – 9.0	7.94	0.5 – 15.1	0	7
8-MLY001.58	6/24/96 TO 11/3/11	23	23	6.29	5.2 – 7.2	6.58	0.1 – 12.1	6	5
8-XIW000.42	1/8/09 to 11/3/11	19	19	6.78	6.1 – 7.2	9.16	5.0 – 13.7	0	0

Time series graphs of all pH and DO data collected at the original listing station, Jacks Creek at station 8-JKC004.15, shows the DO ranging from 0.0 to 13.5 mg/l. (Figure 4) and pH ranged from 5.6 to 7.6 S.U. (Figure 5). The horizontal red line at the DO = 4.0 mark represents the minimum water quality standard. The data points below the DO = 4.0 line are violations of the water quality standard in Figure 4. The horizontal red line at the pH = 6.0 mark represents the minimum water quality standard in Figure 5. The data points below the pH = 6.0 line are violations of the water quality standard in Figure 5.

Figure 4. Time series of DO at **Jacks Creek station 8-JKC004.15.**

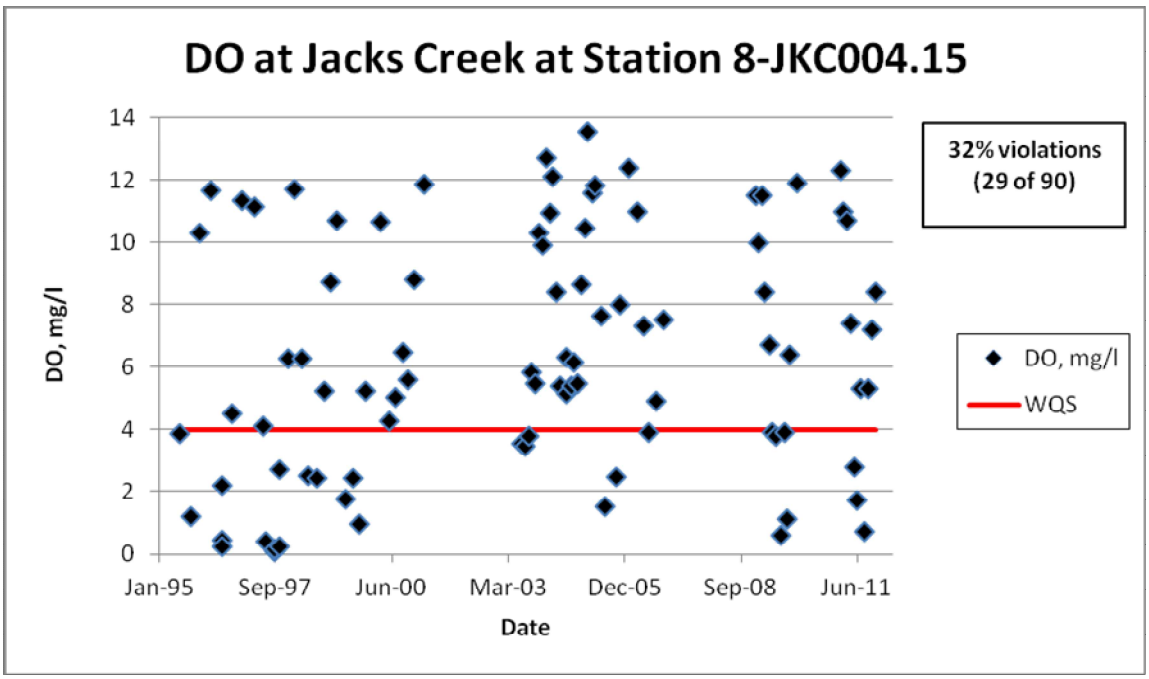
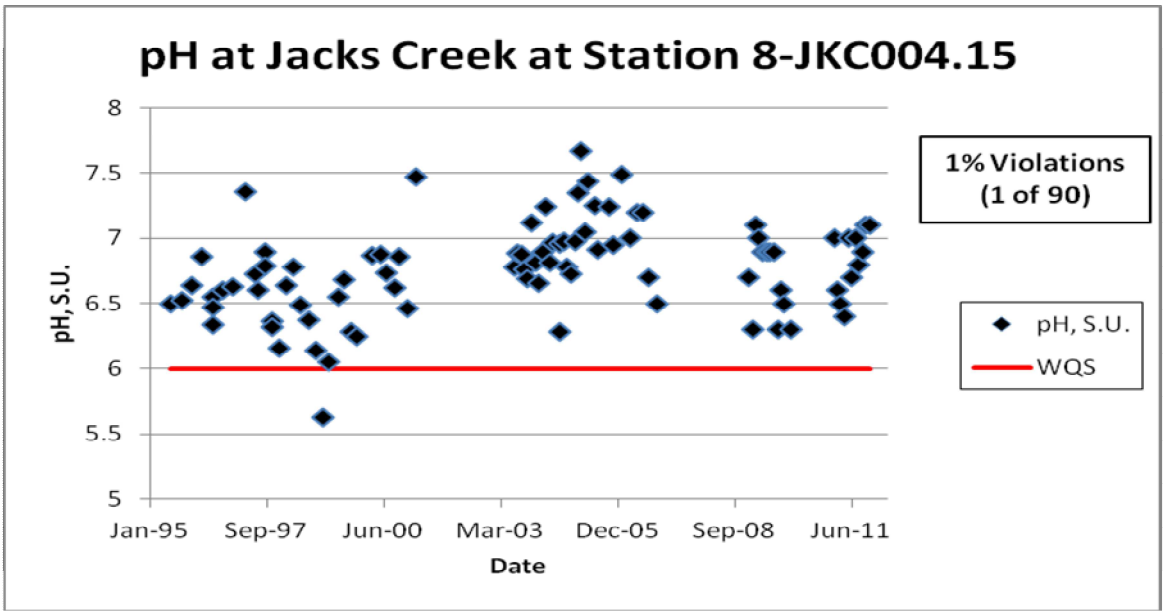


Figure 5. Time series of pH at Jacks Creek station 8-JKC004.15.



3.1. Associated DO and pH of Jacks Creek and Tributaries

DEQ also monitored pH and DO data at seven other station on Jacks, Acquinton, Mallory Creeks and one UT to Jacks Creek for the assessment of low pH and DO due to the natural conditions. Four of seven associated stations exceeded the water quality standards for DO in more than 10 percent of visits. One of seven associated stations (8-MLY001.58 on Mallory Creek) exceeded the pH standard in more than 10 percent of visits. See Figures 6 through 13 for time series of DO and pH at associated Jacks Creek and tributaries stations. Only Mallory Creek at 8-MLY001.58 was charted for pH because it was the only one of seven associated station which violated the pH water quality standard in more than 10 percent of visits.

Figure 6. Time series of DO at Jacks Creek station 8-JKC005.80, minus June 1995 DO of 2.69 mg/l and June 1996 DO of 5.94 mg/l.

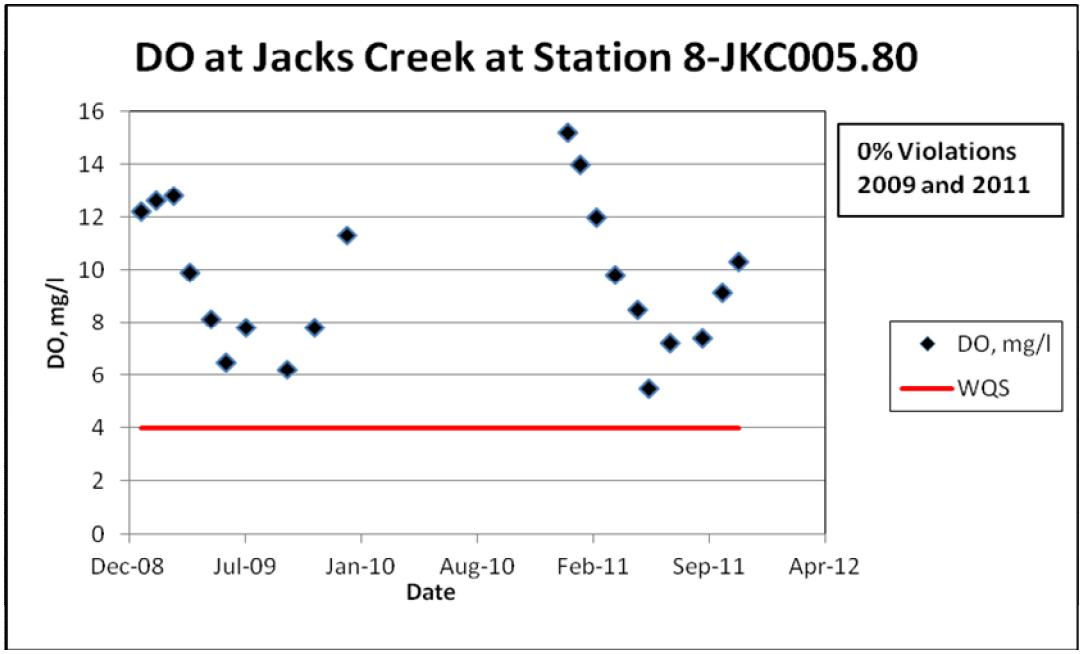


Figure 7. Time series of DO at **Jacks Creek** station **8-JKC007.95.**

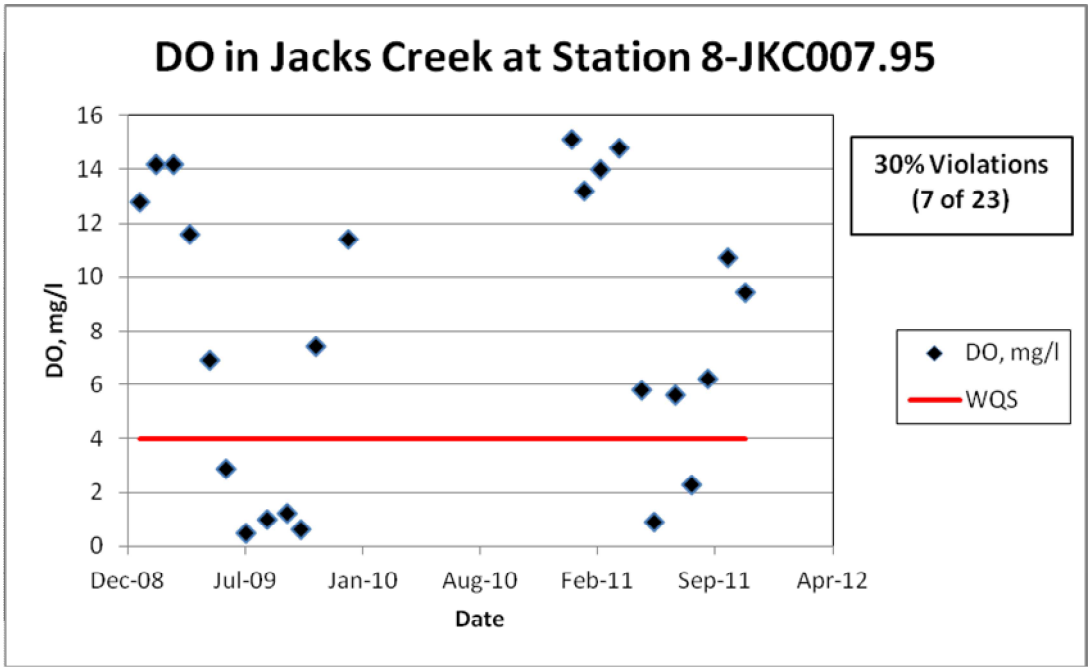


Figure 8. Time series of DO at Acquinton Cr. Station 8-ACQ001.35, minus June 1995 DO of 5.37 mg/l and 1996 DO of 3.98 mg/l.

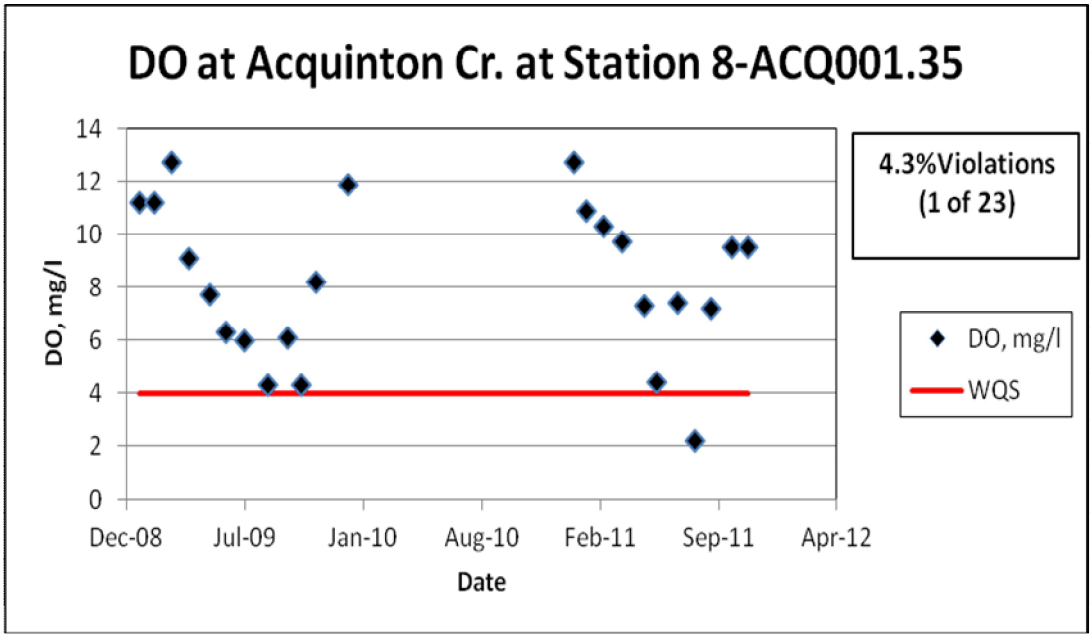


Figure 9. Time series of DO at Acquinton Cr. Station 8-004.43, minus June 1995 DO of 4.96 mg/l and June 1996 DO of 4.30 mg/l.

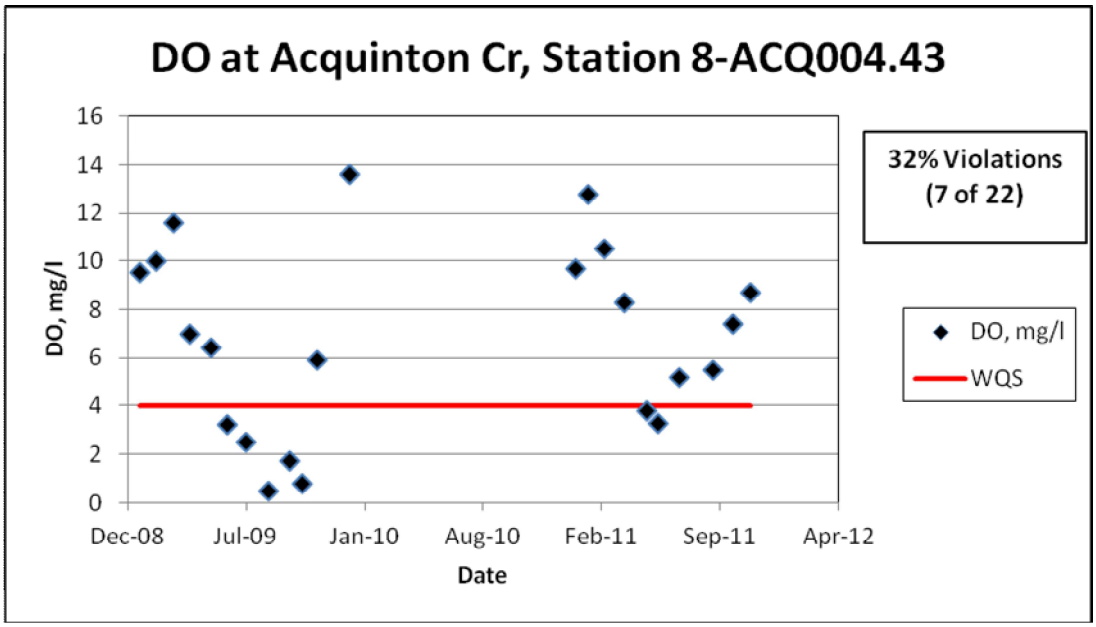


Figure 10. Time series of DO at Acquinton Cr. Station 8-ACQ008.01, minus June 1995 DO of 4.07 mg/l and June 1996 DO of 2.38 mg/l.

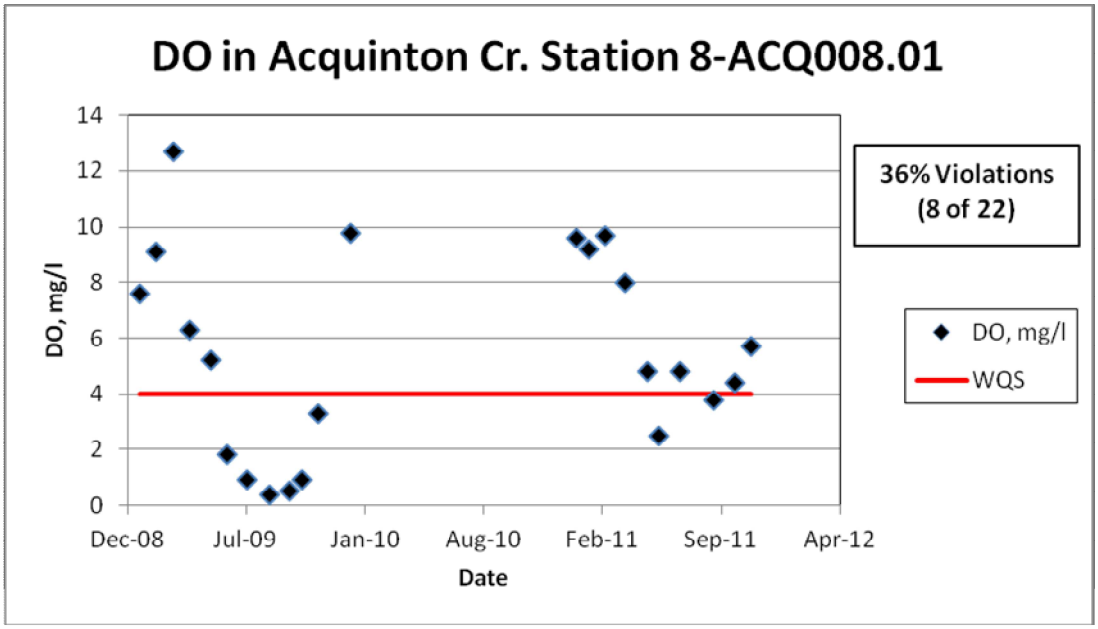


Figure 11. Time series of DO at UT to Jacks Cr. Station 8-XIW000.42.

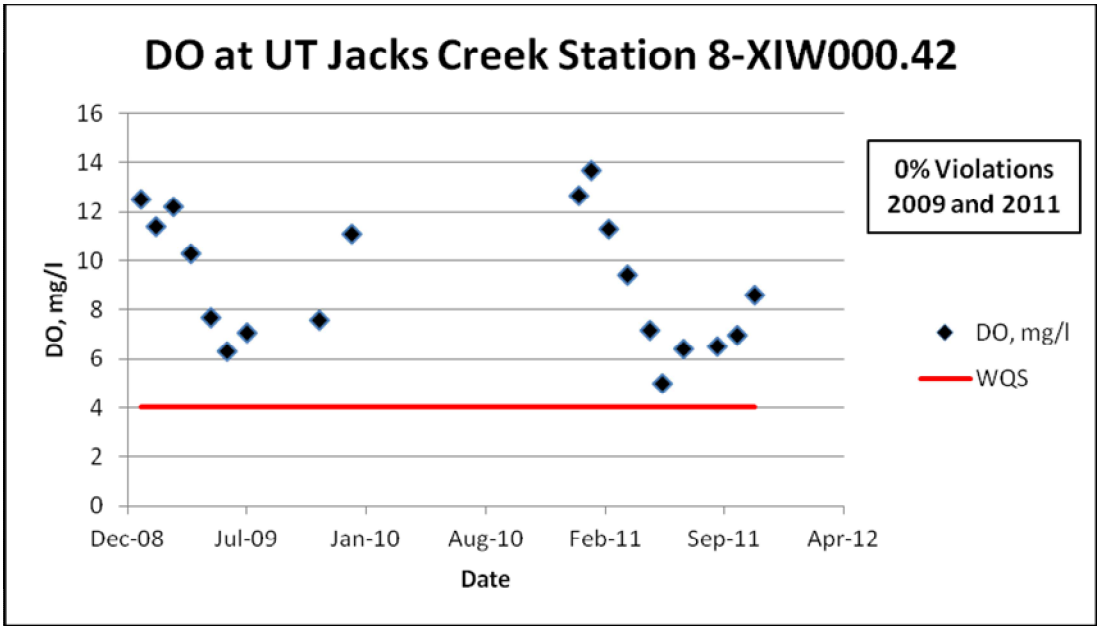


Figure 12. Time series of DO at Mallory Creek Station 8-MLY001.58, minus June 1996 DO of 0.53 mg/l.

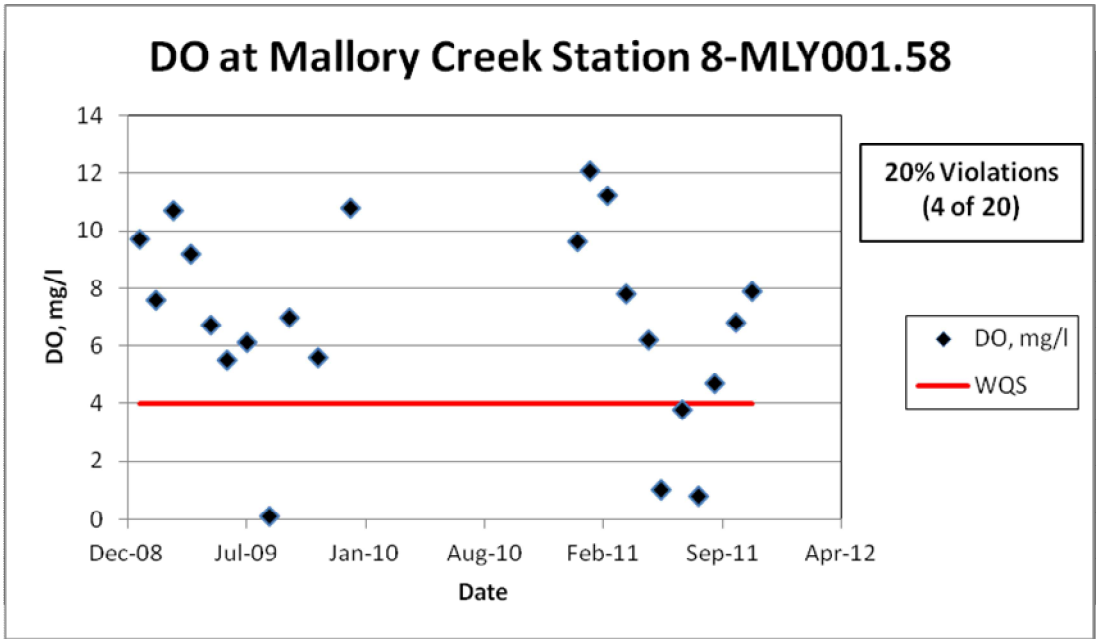
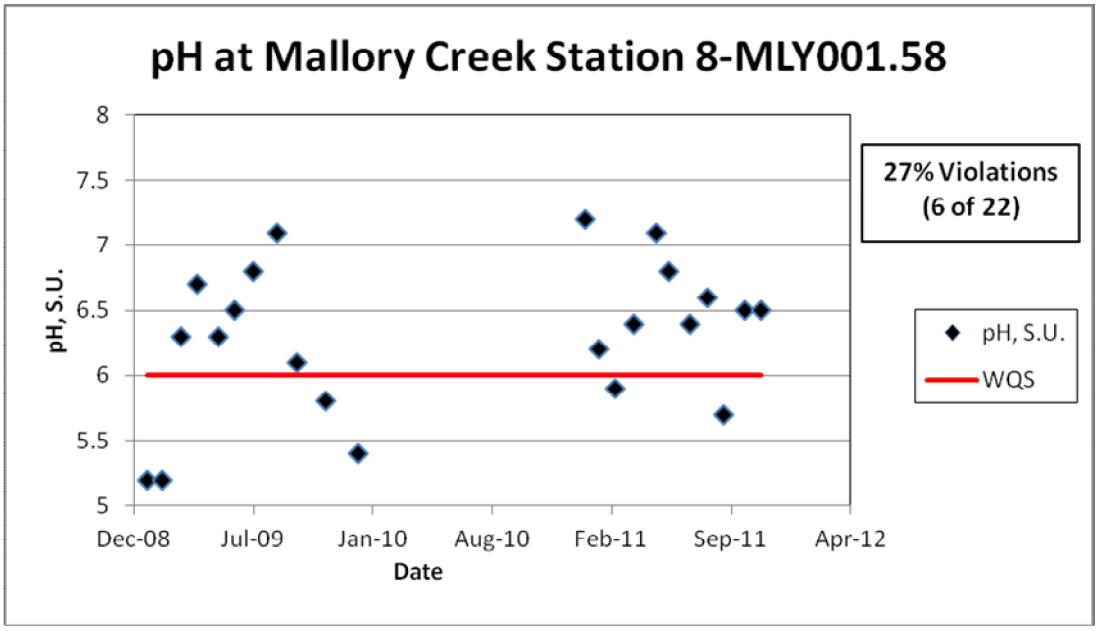


Figure 13. Time series of pH at Mallory Creek Station 8-MLY001.58, minus June 1996 pH of 6.05 S.U.



4. Water Quality Standard

According to Virginia Water Quality Standards (9 VAC 25-260-5), the term *"water quality standards means provisions of state or federal law which consist of a designated use or uses for the waters of the Commonwealth and water quality criteria for such waters based upon such uses. Water quality standards are to protect the public health or welfare, enhance the quality of water and serve the purposes of the State Water Control Law (§62.1-44.2 et seq. of the Code of Virginia) and the federal Clean Water Act (33 USC §1251 et seq.)."*

As stated above, Virginia water quality standards consist of a designated use or uses and water quality criteria. These two parts of the applicable water quality standard are presented in the sections that follow.

4.1. Designated Uses

According to Virginia Water Quality Standards (9 VAC 25-260-10A), *"all state waters are designated for the following uses: recreational uses (e.g., swimming and boating); the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might be reasonably expected to inhabit them; wildlife; and the production of edible and marketable natural resources (e.g., fish and shellfish)."*

As stated above, Jacks Creek must support all designated uses and meet all applicable criteria.

4.2. Applicable Water Quality Criteria

The applicable water quality criteria for DO and pH in the Jacks Creek watershed are an instantaneous minimum DO of 4.0 mg/l and pH from 6.0 SU to 9.0 SU, as in Table 4.

Table 4. Applicable water quality standards

Parameter	Minimum, mg/l	Maximum, mg/l
pH	6.0	9.0
DO	4.0	-

If the waterbody exceeds the criterion listed above in more than 10.5 percent of samples, the waterbody is classified as impaired and natural conditions must be determined or a TMDL must be developed and implemented to bring the waterbody into compliance with the water quality criterion.

5. Assessment of Natural Conditions Affecting low DO - Process for determining if DO and pH impairments in free-flowing streams are due to natural conditions.

The level of dissolved oxygen in a water body is determined by a balance between oxygen-depleting processes (*e.g.*, decomposition and respiration) and oxygen-restoring processes (*e.g.*, aeration and photosynthesis). Certain natural conditions promote a situation where oxygen-restoring processes are not sufficient to overcome the oxygen- depleting processes. The level of pH in a water body is determined by a balance between organic acids produced by decay of vegetative material, and buffering capacity. Conditions in a stream that would typically be associated with naturally low DO and pH include slow-moving, ripple-less waters or wetlands where the decay of organic matter produces organic acids. These situations can be compounded by anthropogenic activities that contribute excessive nutrients or readily available organic matter to these systems. The general approach to determine if DO and pH impairments in streams are due to natural conditions is to assess a series of water quality and hydrologic criteria to determine the likelihood of an anthropogenic source. A logical 4-step process for identifying natural conditions that result in low DO and/or pH levels and for determining the likelihood of anthropogenic impacts that will exacerbate the natural condition is described below.

Step 1. Determine slope and appearance.
Step 2. Determine nutrient levels.
Step 3. Determine degree of seasonal fluctuation (for DO only).
Step 4. Determine anthropogenic impacts.

The results from this methodology (or process or approach) will be used to determine if the stream should be re-classified as Class VII Swamp Waters. Each step is described in detail below.

Procedure for Natural Condition Assessment of low pH and low DO in Virginia Streams

Prepared by Virginia Department of Environmental Quality
October 2004

I. INTRODUCTION

Virginia's list of impaired waters currently shows many waters not supporting the aquatic life use due to exceedances of pH and/or DO criteria that are designed to protect aquatic life in Class III waters. However, there is reason to believe that most of these streams or stream segments have been mis-classified and should more appropriately be classified as Class VII, Swamp Waters. This document presents a procedure for assessing if natural conditions are the cause of the low pH and/or low DO levels in a given stream or stream segment.

The level of dissolved oxygen (DO) in a water body is determined by a balance between oxygen-depleting processes (*e.g.*, decomposition and respiration) and oxygen-restoring processes (*e.g.*, aeration and photosynthesis). Certain natural conditions promote a situation where oxygen-restoring processes are not sufficient to overcome the oxygen-depleting processes. The level of acidity as registered by pH in a water body is determined by a balance between organic acids produced by decay of vegetative material, and buffering capacity.

Conditions in a stream that would typically be associated with naturally low DO and/or naturally low pH include slow-moving, ripple-less waters. In such waters, the decay of organic matter depletes DO at a faster rate than it can be replenished and produces organic acids (tannins, humic and fulvic substances). These situations can be compounded by anthropogenic activities that contribute excessive nutrients or readily available organic matter to these systems.

The general approach to determine if DO and pH impairments in streams are due to natural conditions is to assess a series of water quality and hydrologic criteria to determine the likelihood of an anthropogenic source. A logical 4-step process for identifying natural

conditions that result in low DO and/or pH levels and for determining the likelihood of anthropogenic impacts that will exacerbate the natural condition is described below. DEQ staff is proposing to use this approach to implement State Water Control Law 9 VAC 25-260-55, Implementation Procedure for Dissolved Oxygen Criteria in Waters Naturally Low in Dissolved Oxygen.

Waters that are shown to have naturally low DO and pH levels will be re-classified as Class VII, Swamp Waters, with the associated pH criterion of 4.3 to 9.0 SU. An associated DO criterion is currently being developed from swamp water data. A TMDL is not needed for these waters. An assessment category of 4C will be assigned until the waterbody has been re-classified.

II. Natural Condition Assessment

Following a description of the watershed (including geology, soils, climate, and land use), a description of the DO and/or pH water quality problem (including a data summary, time series and monthly data distributions), and a description of the water quality criteria that were the basis for the impairment determination, the available information should be evaluated in four steps.

Step 1. Determine appearance and flow/slope.

Streams or stream segments that have naturally low DO (< 4 mg/L) and low pH (< 6 SU) are characterized by very low slopes and low velocity flows (flat water with low reaeration rates). Decaying vegetation in such swampy waters provides large inputs of plant material that consumes oxygen as it decays. The decaying vegetation in swamp water also produces acids and decreases pH. Plant materials contain polyphenols such as tannin and lignin. Polyphenols and partially degraded polyphenols build up in the form of tannic acids, humic acids, and fulvic acids that are highly colored. The trees of swamps have higher polyphenolic content than the soft-stemmed vegetation of marshes. Swamp streams (blackwater) are therefore more highly colored and more acidic than marsh streams.

Appearance and flow velocity (or slope if flow velocity is not available) must be identified for each stream or stream segment to be assessed for natural conditions and potential re-classification as Class VII swamp water. This can be done through maps, photos, field measurements or other appropriate means.

Step 2. Determine nutrient levels.

Excessive nutrients can cause a decrease in DO in relatively slow moving systems, where aeration is low. High nutrient levels are an indication of anthropogenic inputs of nitrogen, phosphorus, and possibly organic matter. Nutrient input can stimulate plant growth, and the resulting die-off and decay of excessive plankton or macrophytes can decrease DO levels.

USGS (1999) estimated national background nutrient concentrations in streams and groundwater from undeveloped areas. Average nitrate background concentrations are less than 0.6 mg/L for streams, average total nitrogen (TN) background concentrations are less

than 1.0 mg/L, and average background concentrations of total phosphorus (TP) are less than 0.1 mg/L.

Nutrient levels must be documented for each stream or stream segment to be assessed for natural conditions and potential re-classification as Class VII swamp water. Streams with average concentrations of nutrients greater than the national background concentrations should be further evaluated for potential impacts from anthropogenic sources.

Step 3. Determine degree of seasonal fluctuation (for DO only).

Anthropogenic impacts on DO will likely disrupt the typical seasonal fluctuation seen in the DO concentrations of wetland streams. Seasonal analyses should be conducted for each potential Class VII stream or stream segment to verify that DO is depressed in the summer months and recovers during the winter, as would be expected in natural systems. A weak seasonal pattern could indicate that human inputs from point or nonpoint sources are impacting the seasonal cycle.

Step 4. Determine anthropogenic impacts.

Every effort should be made to identify human impacts that could exacerbate the naturally low DO and/or pH. For example, point sources should be identified and DMR data analyzed to determine if there is any impact on the stream DO or pH concentrations. Land use analysis can also be a valuable tool for identifying potential human impacts.

Lastly, a discussion of acid rain impacts should be included for low pH waters. The format of this discussion can be based either on the process used for the recent Class VII classification of several streams in the Blackwater watershed of the Chowan Basin (letter from DEQ to EPA, 14 October 2003). An alternative is a prototype regional stream comparison developed for Fourmile Creek, White Oak Swamp, Matadequin Creek and Mechumps Creek (all east of the fall line). The example analysis under IV in this document, or the example report prepared for Fourmile Creek, illustrate this approach. For streams west of the fall line, a regional stream comparison for 2004 analyses encompasses Winticomack, Winterpock, and Chickahominy Rivers.

7Q10 Data Screen

If the data warrant it, a data screen should be performed to ensure that the impairment was identified based on valid data. All DO or pH data that violate water quality standards should be screened for flows less than the 7Q10. Data collected on days when flow was < 7Q10 should be eliminated from the data set and the violation rate recalculated accordingly. Only those waters with violation rates determined days with flows > or = 7Q10 flows should be classified as impaired.

In some cases, data were collected when flow was 0 cfs. If the 7Q10 is identified as 0 cfs as well, all data collected under 0 cfs flow would need to be considered in the water quality assessment. In those cases, the impairment should be classified as 4C, impaired due to natural conditions, no TMDL needed. However, a reclassification to Class VII may not always be appropriate.

III. NATURAL CONDITION CONCLUSION MATRIX

The following decision process should be applied for determining whether low pH and/or low DO values are due to natural conditions and justify a reclassification of a stream or stream segment as Class VII, Swamp Water.

If velocity is low or if slope is low (<0.50%) AND
If wetlands are present along stream reach AND
If no point sources or only point sources with minimal impact on DO and pH AND
If nutrients are < typical background

- ❖ average (= assessment period mean) nitrate less than 0.6 mg/L
- ❖ average total nitrogen (TN) less than 1.0 mg/L, and
- ❖ average total phosphorus (TP) are less than 0.1 mg/L AND

For DO: If seasonal fluctuation is normal AND
For pH: If nearby streams without wetlands meet pH criteria OR if no correlation between in-stream pH and rain pH,

THEN determine as impaired due to natural condition
→ assess as category 4C in next assessment
→ initiate WQS reclassification to Class VII Swamp Water
→ get credit under consent decree

The analysis must state the extent of the natural condition based on the criteria outlined above. A map showing land use, point sources, water quality stations and, if necessary, the delineated segment to be classified as swamp water should be included.

In cases where not all of these criteria apply, a case by case argument must be made based on the specific conditions in the watershed.

5.1 Preliminary Data Screen for Low Flow 7Q10

The 7Q10 flow of a stream is the lowest streamflow for seven consecutive days that occurs on average once every ten years. The first step for low flow 7Q10 screening is to determine the most accurate 7Q10 available. The 7Q10 flow for Jacks Creek may be estimated by a drainage area ratio of the Jacks Creek watershed (27.70 mi^2) with the 7Q10 flow at the long-term continuous gaging station Piscataway Creek near Tappahannock, VA, (USGS:01669000), with a drainage area of 28.0 mi^2 and a 7Q10 of 0.50 cfs (2005). Thus the 7Q10 of Jacks Creek is estimated at 0.49 cfs.

The DO Instantaneous Water Quality Standard applies **AT** 7Q10 flow, but **NOT** below 7Q10 flow (9 VAC 25-260-50 ***). Therefore in streams where the 7Q10 > 0.0 cfs, DO less than 4.0 mg/l taken at flows below 7Q10 are not water quality standard violations. However, in streams where the 7Q10 = 0.0 cfs, **ALL** DO data < 4.0 mg/l are standard violations, even if the flow = 0 cfs when the DO was taken.

No Jacks Creek and tributaries pH or DO water quality data were obtained at flows below 7Q10, therefore no data were removed.

5.2 Low slope, Swamps, Wetlands or Large Forested Areas

The percent slope of Jacks Creek and tributaries ranged from 0.21% to 0.48% slope (Table 5). This is lower than the defined low slope criteria of 0.50%. Decomposition of the large inputs of decaying vegetation from areas of forested land with swamps and heavy tree canopy throughout the watersheds increase oxygen

demand and lower DO as they decay, as well as contribute to the low pH by creation of natural weak organic acids (tannic, humic and fulvic acids) during decomposition of the decaying vegetation. These are not considered anthropogenic impacts.

Table 5. Calculated percent slopes for Jacks Creek and tributaries.

Stream	% Slope	Upstream Elevation (Feet) at Rivermile (RM)	Downstream Elevation (Feet) at Rivermile (RM)
Jacks Creek	0.32	100' at RM 8.89	10' at RM 3.69
Acquinton Creek	0.21	120' at RM 9.66	20' at RM 0.50
Mallory Creek	0.48	100' at RM 3.85	10' at RM 0.27
UT to Jacks Creek	0.48	100' at RM 2.23	30' at Jacks Cr RM 5.38 (0.54 miles downstream of mouth of UT to Jacks Cr)

Visual inspection of Jacks Creek revealed swampy areas with heavy tree canopy. Decomposition of vegetative matter from large swampy areas lowers DO and pH as decay occurs. (Figures 14 - 17).

Figure 14. Jacks Creek, Rt. 621 Upstream.

Figure 15. Acquinton Creek at Rt. 629, Upstream.

Figure 16. Acquinton Creek at Rt. 600, Upstream.

Figure 17. Mallory Creek at Rt. 632, Upstream.

5.3 Instream Nutrients

The VADEQ collected nutrient data from the original listing station 8-JKC004.15 (June 1995 to December 2009 (Table 6). The average total nitrogen (TN), nitrate and total phosphorus (TP) concentrations are below the USGS (1999) national background nutrient concentrations in streams from undeveloped areas with levels of TN < 1.0 mg/l, nitrate < 0.6 mg/l and TP < 0.1 mg/l. These low nutrient levels are not indicative of human impact.

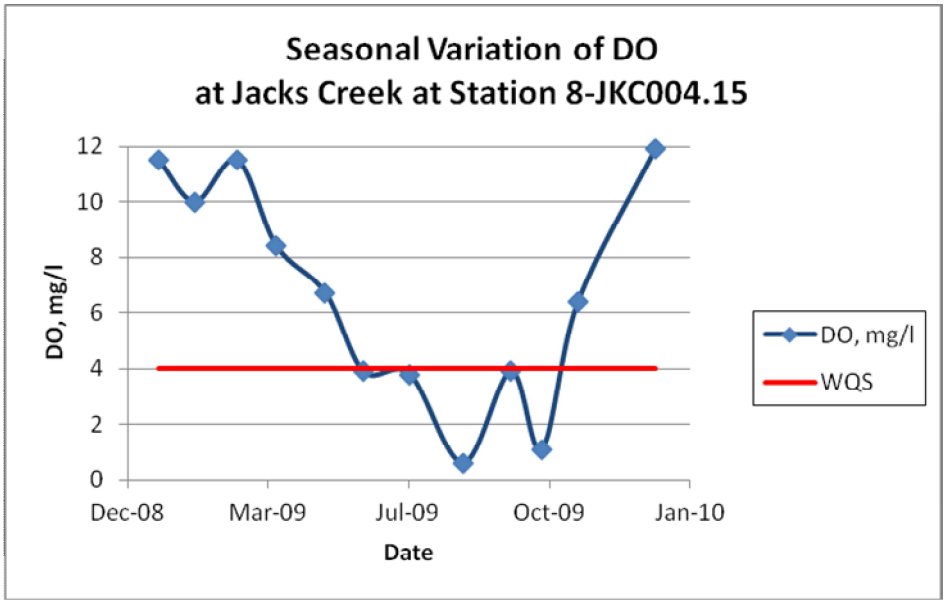
Table 6. Instream Nutrients of Jacks Creek 8-JKC004.15.

Parameter	Average Conc.	Number
Total Phosphorus	**0.074 mg/l**	(n=52)
Orthophosphorus	0.045 mg/l	(n=42)
Total Kjeldahl Nitrogen	0.681 mg/l	(n=42)
Ammonia as N	0.058 mg/l	(n=52)
Nitrate as N	**0.048 mg/l**	(n=42)
Nitrite as N	0.007 mg/l	(n=42)
TN (TKN + NO_3 + NO_2)	**0.736 mg/l**	(n=52)
Nitrite + Nitrate, Total as N	0.061 mg/l	(n=42)

5.4 Natural Seasonal DO Fluctuation

The 2009 DO data collected at the Jacks Creek original listing station 8-JKC004.15 were graphed to demonstrate the natural seasonal DO fluctuation due to the inverse relationship between water temperature and DO. DO is high in the winter months while water temperatures are low, and low in the summer months when water temperatures are high. This is depicted in Figure 18.

Figure 18. Seasonal DO Variation at Jacks Creek at Rt. 621, January – December 2009.



5.5 Impact from Point Source Dischargers and Land Use

There are no active permitted point source dischargers in the Jacks Creek watershed.

The watershed is approximately 17726 acres (27.70 mi^2) in size and is predominately forested (60 percent). Agriculture comprises 16 percent of the watershed, with 11 percent cropland and 5 percent pasture/hayland. Urban areas compose approximately 4 percent of the land base. The remaining 20 percent of the watershed is comprised of 9 percent other grasses and 11 percent wetlands, Land use was not considered to have significantly impacted the swampwater conditions of Jacks Creek and tributaries.

6. CONCLUSION

The following decision process is proposed for determining whether low DO values are due to natural conditions:

If slope is low (<0.50) AND
If wetlands or large areas of forested land are present along stream reach AND
If no point sources or point sources with minimal impact on DO AND
If nutrients are < typical background
- ❖ average (= assessment period mean) nitrate less than 0.6 mg/L
- ❖ average total nitrogen (TN) less than 1.0 mg/L, and
- ❖ average total phosphorus (TP) are equal to or less than 0.1 mg/L AND

If nearby streams without wetlands meet DO criteria,

THEN determine as impaired due to natural condition
→ assess as category 4C in next assessment
→ initiate WQS reclassification to Class VII Swamp Water
→ get credit under consent decree

No Jacks Creek pH or DO water quality data, standard violations or non-violations were obtained at flows below 7Q10, therefore no data were removed.

The percent slope of Jacks Creek and tributaries ranged from 0.21% to 0.48% slope. This is lower than the defined low slope criteria of 0.50%. Decomposition of the large inputs of decaying vegetation from areas of forested land with swamps and heavy tree canopy throughout the watersheds increase oxygen demand and lower DO as they decay, as well as contribute to the low pH by creation of natural weak organic acids (tannic, humic and fulvic acids) during decomposition of the decaying vegetation. These are not considered anthropogenic impacts.

The average total nitrogen, nitrate and total phosphorus concentrations in Jacks creek are below the USGS (1999) national background nutrient concentrations in streams from undeveloped areas with levels of TN < 1.0 mg/l, nitrate < 0.6 mg/l and TP < 0.1 mg/l. These low nutrient levels are not indicative of human impact.

Jacks Creek exhibits natural seasonal DO fluctuation due to the inverse relationship between water temperature and DO.

There are no active permitted point source dischargers in the Jacks Creek watershed.

The watershed is approximately 17726 acres (27.70 mi^2) in size and is predominately forested (60 percent). Agriculture comprises 16 percent of the watershed, with 11 percent cropland and 5 percent pasture/hayland. Urban areas compose approximately 4 percent of the land base. The remaining 20 percent of the watershed is comprised of 9 percent other grasses and 11 percent wetlands, Land use was not considered to have significantly impacted the swampwater conditions of Jacks Creek and tributaries.

Based on the above information, a change in the water quality standards classification to Class VII Swampwater due to natural conditions, rather than a TMDL, is indicated for Jacks Creek and tributaries located in waterbody identification codes (WBID) VAP-F12R, for a total of 67.88 rivermiles. The unnamed tributary to Jacks Creek entering at RM 5.92 was included in the Class VII designation because the minimum DO approached the DO water quality standard and the land use, percent slope and other factors were consistent with swampwater conditions in the rest of the watershed. If there is a 305(b)/303(d) assessment prior to the reclassification, Jacks Creek will be assessed as Category 4C, Impaired due to natural condition, no TMDL needed.

DEQ performed the assessment of the Jacks Creek and tributaries low DO and low pH natural condition in lieu of a TMDL. Therefore neither a TMDL Technical Advisory Committee (TAC) meeting nor a public meeting was involved. Public participation will occur during the next water quality standards triennial review process.

7. References

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USGS (United States Geological Survey), National Background Nutrient Concentrations in Streams from Undeveloped Areas. 1999.

VADCR (Virginia Department of Conservation and recreation) http://www.dcr.virginia.gov/natural_heritage/documents/overviewPhysiography_vegetation.pdf (Accessed 09/04/2008)

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